HOW CAN WE ESTIMATE THE COST OF NATURE CONSERVATION?—SWEDISH CONDITIONS

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ABSTRACT. —In Sweden, domestic resources of wood from deciduous species are limited. Because of high demands for the hardwoods both from forest industries and nature conservation, a solution that satisfies both parts is needed. This paper gives an example of how we approach the problem of evaluating the cost of nature conservation at the stand level. There are three main parts identified in the estimate: (1) the values of the selected trees themselves, (2) the cost of withdrawing their influence areas from future forest production, and (3) the costs for special management in order to keep the selected trees in desirable condition.

INTRODUCTION

Hardwoods constitute 15.5 percent of the total growing tree stock in Sweden, which in 1990 amounted to 2.7 billion cubic meters (m^3) (Berg et al. 1996). The main hardwood species is birch, both silver birch (*Betula pendula* Roth.) and downy birch (*B. pubescens* Ehrh.), constituting two thirds of the hardwood volume. Other important deciduous species for forestry in Sweden are, in order of decreasing volume, aspen (*Populus tremula* L.), alder (*Alnus glutinosa* (L.) Gaertn. and *A. incana* (L.) Moench.), oak (*Quercus robur* L., and *Q. petraea* (Matt.) Liebl.), beech (*Fagus sylvatica* L.), and ash (*Fraxinus excelsior* L.), (National Board of Forestry 1996b). The consumption of broad-leaved pulpwood and timber exceeds the domestic harvest by 2 to 3 million m^3 annually. The deficit is mainly imported as birch from the Baltic States and Russia. In addition, as a member of the European Union, Sweden is involved in a situation where the demand for wood produced within the community will increase because of a policy aiming at decreasing the importation of tropical hardwoods.

In recent times, the awareness of and demands for biological diversity have increased significantly. Consequently, the pressure on the hardwoods has become higher. The Swedish Forestry Act of 1994 (National Board of Forestry 1994) stresses that hardwoods should be kept in conifer stands if the site is suitable and that nature and culture conservation demands shall be respected to a certain limit by the forest owner. Other organizations have complemented the guidelines of the act, although to different levels. The forest companies are also planning and using silvicultural methods that consider nature conservation. Because of the limited resources of wood from deciduous species in Sweden and high demands both from forest industries and nature conservation, a solution that satisfies both parts is of utmost importance. Some of the activities within the newly started south Swedish project "Improved utilization of hardwood for industrial processing" work in this field.

The aim of this paper is to compile and structure the varying demands placed on nature conservation from different sources and to describe and evaluate the costs involved when taking the demands into consideration. Realistic case studies will examine the costs of nature conservation.

RECOMMENDATIONS FOR NATURE CONSERVATION

Due to a widespread human population and a culture where wood has been a main prerequisite for survival, virgin forests in Sweden are rare and mainly located near the timberline in the mountains. Sweden had already introduced forestry in the beginning of this century to counteract the threat that human culture has presented to the forests. It has forced the forest owner to perform reforestation. Since then, the standing tree volume and annual increment has increased considerably. Thus, Sweden has had sustainable forestry in terms of wood production for almost a

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century. However, in the view of the Rio Declaration of 1992 (United Nations 1992; Schlaepfer 1997), sustainability includes more aspects of forestry than wood production. Therefore, a major change in the Forestry Act was adopted in 1994: environmental aspects, in terms of preserving biological diversity, were given the same importance as wood production. To fulfill the environmental aspects, two main types of actions are required: (1) particularly valuable biotopes (key habitats) had to be withdrawn from forestry; (2) general environmental considerations and measures had to be undertaken in connection with silvicultural treatments of all stands.

Although there is a general understanding of the need to preserve biotopes, there are discussions on how to cover the costs and the time available for completion. An estimated 5 to 10 percent of the productive forest area will be withdrawn from forestry as a result of this preservation. Many different ideas exist on how to undertake general environmental considerations and measures in connection with stand treatments. To solve this question, attempts have been made to work out an agreement to certify Swedish forestry according to the guidelines of the Forest Stewardship Council (FSC). So far this has failed, and a solution is not to be expected shortly. Therefore, the following ideas, presented by various organizations, will still be under debate.

The National Board of Forestry is the authority responsible for implementing the Forestry Act. Since the act does not prescribe details, the Board has worked out an activity plan comprising several recommendations on different scale levels (i.e., landscape and estate scales) (National Board of Forestry 1996a). The act stresses the need for more old, big trees and for an increasing amount of dead wood. This demand is especially valid for broad-leaved trees, as an increasing proportion of these should, in general, favor biodiversity. Examples are given on how to achieve the biodiversity goal on different types of estates. The Forestry Act gives the following recommendations for preserving trees on an estate in southern Sweden where broad-leaved trees dominate the landscape:

- In conifer stands, five trees per hectare (ha) should be left as “eternity trees.” Birch, aspen, willow, and wide-crowned spruces are considered the best choices.
- In stands with broad-leaved species, 10 trees per ha in terms of wide-crowned oaks, aspen, and birch are given priority and should remain.
- Finally, in mixed stands with an extremely large number of different tree species, 15 big trees per ha are recommended to be left.

So, depending on the prerequisites, a varying number of trees per ha should not be harvested to promote biodiversity.

The Swedish Society for the Conservation of Nature, in a joint document together with World Wildlife Fund (1995), has presented a demand for leaving at least 10 percent of the standing volume measured as basal area as a link between the old and the new stand. Therefore, at least 10 trees per ha should be left on the clearcut where possible. In combination with this, 20 old “eternity trees” per ha should, as an average, be left in connection with clearcuts. Their function is to turn into dead wood in the future. In order to immediately increase the amount of dead wood, three “tall stumps” per ha should also be produced when clearcutting.

The worldwide demand for sustainable forestry has been a challenge to Swedish forest companies like AssiDomän, Korsnäs, MoDo, SCA, and Stora. Environmental policies have been published to meet the demands. For the forestry part, these policies generally have a structure comprising ecological landscape planning, nature-like silvicultural methods, better site adaptation in terms of the right species in relation to site, and ecological or environmental final accounts. The idea is to show the improvements for a number of ecological goals by the annual accounts. The companies are generally prepared to set aside endangered biotopes to a noticeable extent. Although a number of ecological goals and considerations are clearly described, the general precautions taken in connection with silvicultural treatments are normally not specified. However, the policies mention leaving trees, preferably those in groups, in connection with harvest operations. At least one company, Korsnäs, is already certified according to ISO 14001 for the forestry part.

Private forest owners, many of whom are organized within Forest Owners’ Associations, own one-half of the productive forests. Their forests are generally more diverse in terms of management intensity and many other

aspects compared with the company forests. The average estate consists of only 50 hectares, which constitutes a specific problem in the case of forestry certification. Voluntary nature conservation agreements and ecological forest inventory plans are two instruments used to reach the combined production and environmental goals. A voluntary nature conservation agreement is a 1-year agreement (which can be prolonged 1 year at a time) between the forest owner and his association. In these agreements, the owner must leave at least 5 percent of the area for the single purpose of enriching biological diversity. They also must be more ambitious in terms of environmental precautions than demanded by the Forestry Act on the rest of their lands. However, these agreements are not sufficient for satisfactory protection, and these organizations state very clearly that it must be the community that takes overall responsibility for reserving sufficient areas to protect endangered biotopes. As the Forest Owners' Associations are managing small estates, it is natural that they claim that ecological considerations must be seen from a landscape perspective, from which ecological inventory plans are made up on the estate level. The plans shall promote long-term sustainable forest management on the different estates within their own prerequisites. Recently, the Forest Owners' Associations declared that private forest owners cannot meet the economic responsibilities required for a FSC certification. It is interesting to note that one of the associations, Södra, recently stated that many forest owners, in the trend towards more nature-like silvicultural methods, have reduced reforestation measures and noncommercial thinnings to a degree where wood production might be endangered, presumably without any noticeable ecological advantages.

ECONOMIC ELEMENTS OF THE NATURE CONSERVATION COST

Among possible economic elements influenced by nature conservation, three were identified as important for the economy of forestry. First, the standing trees themselves constitute a significant value, which increases with age both in forestry and nature conservation. Second, the cost of withdrawing the influence areas of trees from forest production (i.e., the expected land value) has to be estimated. The influence areas can be separated in light competition areas and nutrient/water competition areas. In general, the final spacing indicates the influence areas of mature trees. Third, the costs for additional management directed towards protecting selected preserved trees have to be considered. In our case studies, we assumed that this third element was close to zero (i.e., income and costs were nearly equal). It is, of course, possible to find other elements that can affect forest economy, such as more expensive logging caused by the requirement to respect nature conservation. However, it was assumed that these other costs could only marginally influence the calculations, and they were consequently left without further attention.

CASE STUDIES

With the following two case studies of forest stands, we discuss the effects of rotation time and wood value on the cost for nature conservation. Oak forests, with long rotation periods (often more than 120 years) and high wood values at later stages, will be compared with birch, a forest type with faster rotation (about 50 years) but lower final wood values. With these case studies, we intend to demonstrate the effect of general consideration to nature conservation. Areas set aside as reserves or key habitats are not included in the discussion. In addition to the proposed number of preserved trees per ha, 10 and 20, we have also used 3 trees as a minimum number for nature conservation.

Stand of Old Oaks

This type of stand was included because oaks represent a hardwood species with high wood value, up to 2,700 SEK per m^3 (about $340) for veneer logs. Oaks are also common in the southern part of Sweden and old specimens have a significant biological diversity value (Weslien 1993; Ahlén et al. 1996).

The selected stand is about 120 years old and situated close to the Ekebo field station of the Forestry Research Institute of Sweden (latitude 55°57'N.; longitude 13°07'E.; alt. 80 m). The oaks are growing on a fresh and well-drained fertile soil (productivity 5 to 6 m^3 of stemwood per ha per year), but have only been extensively managed.

Thus the quality of the trees is not optimal. However, this is a common situation, so the selected stand can be considered as representative. The trees have reached their climax, and an extension of rotation time will not improve quality but instead lead to degeneration of crowns and adventitious branching. The spacing is somewhat too dense for the final stage of the stand and increases the risk of crown competition and dying branches. Below the oaks, a second tree layer of mainly young ash plants has naturally regenerated.

In two circular sample plots of 314 square meters (m^2) each, all trees were counted and measured for diameter (Table 1). On these plots, a total of five old, big oaks were found. These trees were measured for height, diameter, crown projection area, crown length, and value (Table 2). Table 1 shows a dense new plant generation with a high value of basal area where ash and hazel dominate. The spacing of the old oaks is about 70 per ha with a mean tree basal area of 33 square decimeters. The stand basal area of the top layer trees can be estimated to 23 m^2 per ha. In an optimal situation there should be fewer but thicker trees and a basal area of about 20 m^2 per ha. The importance of thick stems for high wood values can be seen from Table 2. Not only was the stand denser than recommended, the trees were also grouped and the crowns competed with each other. On the sample plots, the total crown projection area was 85 percent of the sum of the individuals, i.e., 30 percent of the crown projection area had competition from a neighboring tree. The wood values of the oaks (Table 2) were only about half of what can be expected for corresponding diameters in well-managed stands, except for tree 2:146, which contained a veneer log and thus reached 85 percent of expected value. A mean wood value of 2,281 SEK and 70 oaks per ha gives a total wood value of 160,000 SEK per ha.

Table 1.—Stem number (n), diameter of stem of mean basal area (Dg), and basal area (G) for the different tree species found on the sample plots. All trees with a height of 1.3 meters (m) or more are included.

Tree species	n	Dg	G
	no ha^{-1}	*cm*	*m^2 ha^{-1}*
Ash (*Fraxinus excelsior*)	5,396	1.8	1.48
Beech (*Fagus sylvatica*)	48	2.0	0.02
Bird cherry (*Prunus padus*)	143	2.8	0.09
Crab apple (*Malus sylvestris*)	127	6.4	0.56
Hawthorn (*Crataegus* sp.)	128	1.7	0.02
Hazel (*Corylus avellana*)	700	2.3	0.30
Norway maple (*Acer platanoides*)	32	2.7	0.02
Pedunculate oak (*Quercus robur*)	143	46.0	26.4
Rowan (*Sorbus aucuparia*)	96	3.5	0.09
Sallow (*Salix caprea*)	32	2.8	0.02
Silver birch (*Betula pendula*)	175	3.8	0.12
Wild cherry (*Prunus avium*)	112	3.8	0.32
Totals and mean	7,132	7.2	29.4

Table 2.—Data on the five dominating oaks on the sample plots. The following characters were recorded and estimated: diameter in breast-height on bark (d.b.h.), tree height above ground (H), live crown base (Hc), crown projection area (Cpa), tree volume under bark (V) calculated from volume functions of Hagberg and Matérn (1975) and bark functions of Söderberg (1986), and tree value on root as estimated by a professional log purchaser.

Tree no	d.b.h.	H	Hc	Cpa	V	Value	
	cm	- - - - *m* - - - -		*(m^2)*	*(m^3)*	*SEK*	*US$*
1:38	58.3	25.0	3.8	43.5	2.97	1,051	133
1:117	73.2	25.5	2.3	151.3	5.13	2,822	357
1:220	51.3	21.5	5.0	76.0	1.98	703	90
2:89	70.0	26.2	3.0	100.1	4.71	2,686	340
2:146	69.7	24.5	6.9	114.2	4.46	4,143	524
Mean	64.5	24.5	4.2	97.0	3.85	2,281	289
Standard Deviation	9.3	1.8	1.8	40.5	1.32	1,408	178

The expected land value has been calculated with information from Carbonnier (1975), Møller Madsen (1994), and Persson (1996).[2] By using the current price list (1996/97) of the Forest Owners' Association Södra in southern Sweden, we obtained the figures of Table 3 on net outcome and expected land value at different rates of interest. The economic consequences of leaving 3, 10, or 20 oaks per ha in the actual stand at 2 percent rate of interest have been compiled in Table 4.

[2] Torvald Persson. 1996. Empirical data. Work performed within the commissioned south Swedish project "Improved utilization of hardwood for industrial processing." Södra. Personal communication.

Table 3.—Expected land value of future oak forestry at Ekebo with different rates of interest. For establishment and precommercial thinning of oak, a subsidy with 80 percent of the costs can be obtained, and this is included below.

Year	Measure	Net outcome	Rate of interest		
			2 percent	3 percent	4 percent
			- - - - - - - - - *SEK / US$* - - - - - - - - -		
0	sowing + fencing	-4,000/-506	-4,000/-506	-4,000/-506	-4,000/-506
10	precommercial thinning	-500/-63	-410/-52	-372/-47	-338/-43
15	precommercial thinning	-500/-63	-372/-47	-321/-41	-278/-35
20	thinning	-1,954/-247	-1,315/-166	-1,082/-137	-892/-113
25	thinning + pruning	-4,056/-513	-2,472/-313	-1,938/-245	-1,521/-193
30	thinning	-408/-52	-225/-28	-168/-21	-126/-16
35	thinning + pruning etc	-5,792/-733	-2,896/-367	-2,058/-261	-1,468/-186
40	thinning	-476/-60	-216/-27	-146/-18	-99/-13
45	thinning	385/49	158/20	102/13	66/8
55	thinning	2,970/376	999/126	584/74	343/43
65	thinning	5,455/691	1,506/191	799/101	426/54
75	thinning	8,794/1,113	1,991/252	958/121	464/59
85	thinning	12,003/1,519	2,230/282	973/123	428/54
100	thinning	25,959/3,286	3,583/454	1,351/171	514/65
130	final cutting	267,703/3,3886	20,400/2,582	5,739/726	1,634/207
Total		305,583/38,683	18,961/2,401	421/53	-4,847/-615

Table 4.—The cost of nature conservation, expressed as leaving 3, 10 or 20 trees per ha at final felling, in the oak forest at Ekebo. The economic elements consist of value of trees removed from forestry (Tree value) and expected land value at 2 percent rate of interest (Land value).

Economic element	3 trees		10 trees		20 trees	
	SEK	*US$*	*SEK*	*US$*	*SEK*	*US$*
			Evenly distributed trees			
Tree value	6,843	866	22,810	2,887	45,620	5,775
Land value	813	103	2,709	686	343	5,417
Total	7,656	969	25,519	3,230	51,037	6,461
percent of future net outcome	2.5	2.5	8.4	8.4	16.7	16.7
			Grouped trees			
Tree value	6,843	866	22,810	2,887	45,620	5,775
Land value	691	87	2,302	291	4,605	583
Total	7,534	953	25,112	3,178	50,225	6,358
percent of future net outcome	2.5	2.5	8.2	8.2	16.4	16.4

The general consideration to nature conservation that can be called for from the forest owner may not severely prevent forestry. The demands must be reasonable. These guidelines suggest that 20 or 10 oaks per ha, or 10 percent of basal area, reserved for conservation purposes is not realistic for a rational economic forestry. Three trees is a more realistic figure to negotiate. If we consider a well-managed stand with 50 stems per ha remaining at the time of final cutting, the demand of 10 and 20 trees is even more unrealistic. These trees can be expected to have a final value of about 7,000 SEK each, which means that 40 percent or 140,000 SEK will be directly withdrawn with 20 trees from the landowner. Grouping the reserved trees had small effects in this case but will undeniably facilitate future logging.

Stand of Mature Birches

A birch stand was included because the two Swedish birch species alone constitute two-thirds of the hardwood volume in the country (Berg et al. 1996). The selected stand originates from crossings of plus trees of both silver birch and pubescent birch. The existing stand consists mainly of silver birch since it has superior growth. The original spacing was 7,000 plants per ha, which has been reduced to just below 200 trees today by several cleanings and thinnings (the stand is now 48 years old). The stand is located on a gentle east slope of the small hill Konga Klint at an altitude of about 135 meters (m) (latitude 55°58'N.; longitude 13°11'E.). Because of the plant material and proper management, the quality of the birches is significantly higher than generally found in the region. The current spacing is also sparser than normally recommended. The site index corresponds to a mean annual increment of wood of about 7 m^3 per ha per year.

A circular sample plot of 707 m^2 was placed in a representative part of the stand. Table 5 presents data describing this area. Wood values of the trees were calculated from empirical data on well-managed birch stands prepared by Torvald Persson, Södra (1996). Thus the calculated value and real value may differ somewhat.

Table 5.—Stand data on the birches at Konga Klint recorded in March 1997

Stand character	On the plot (707 m^2)	Per hectare
Number of stems	13	184
Diameter of stem of mean basal area (cm)	30.7	30.7
Dominant height (m)	26.0	26.0
Basal area (m^2)	0.96	13.6
Volume on bark (m^3)	11.0	156
Crown projection area (m^2)	311	4,400
Mean wood value per tree (SEK/$)	200/25	200/25
Total wood value (SEK/$)	2,600/329	37,000/4,684

Because the stand has not been optimally thinned, the rotation time for the stand will be extended about 12 years to 60 years, with no further thinnings. In order to estimate the dimensions and values of the birches at 60 years of age the following assumptions were made: (1) the height growth during 12 years on the actual site index was estimated to 2.2 m from Swedish yield tables (Fries 1964); (2) the diameter growth of the stem of mean basal area was found to be about 4 centimeters (cm) in 12 years in the age 50–60 years for the actual site index (Fries 1964; Oikarinen 1983); (3) individual wood values were taken from empirical curves for well-managed birches in southern Sweden prepared by Torvald Persson (1996).

With the above-mentioned assumptions, the wood value of the birches on the sample plot will increase from 2,600 SEK today to 4,000 SEK after 12 years, which corresponds to 57,000 SEK per ha. Because of high tree vitality and sparse spacing, with only 44 percent crown projection per unit of ground area, the growth calculations are probably underestimates. The fast increase in wood value can be explained by the fact that the butt log of most trees will

grow into the valuable veneer log assortment where the minimum diameter is 30 cm on bark. The expected land value (Table 6) was calculated by using information from Fries (1964) and Torvald Persson, (1996).

Table 6.—Expected land value of birch forestry at Konga Klint with different rates of interest. The thinning grades were 30–35 percent of standing tree volume and total wood production 400 m^3 during 50 years. The felling costs were estimated to 250, 170, 150, 110, and 100 SEK per m^3 at 15, 20, 25, 35, and 50 years of age, respectively. Final stem number is estimated to 200 per ha.

Year	Measure	Net outcome	Rate of interest		
			2 percent	3 percent	4 percent
			- - - - - - - - - *SEK / US$* - - - - - - - - - -		
0	natural regeneration	0/0	0/0	0/0	0/0
7	precommercial thinning	-3,000/-380	-2,612/-331	-2,439/-309	-2,280/-289
10	precommercial thinning	-1,000/-127	-820/-104	-744/-94	-676/-86
15	thinning	240/30	178/23	154/19	133/17
20	thinning	3,780/478	2,544/322	2,093/265	1,725/218
25	thinning	4,070/515	2,481/314	1,944/246	1,527/193
35	thinning	7,950/1006	3975/503	2825/358	2015/255
50	final cutting	7,5593/9569	28085/3555	17243/2183	10637/1346
Total		87,633/11,091	33,831/4,282	21,076/2,668	13,081/1,654

The economic consequences of keeping 3, 10, or 20 birches per ha on the site at 2 percent rate of interest can be seen from Table 7. Because of small overlapping of projected crown areas at the final harvest, no alternative of grouping trees was included.

Table 7.—The cost for forestry of leaving 3, 10, or 20 trees per ha at final felling in the birch stand at Konga Klint. The chosen rate of interest is 2 percent.

Economic element	3 trees		10 trees		20 trees	
	SEK	*US$*	*SEK*	*US$*	*SEK*	*US$*
Tree value	930	118	3,098	392	6,196	784
Land value	507	64	1,692	214	3,383	428
Total	1,437	182	4,790	606	9,579	1,212
percent of net outcome	1.6	1.6	5.3	5.3	10.6	10.6

In comparison with the oak stand, the values themselves are lower, and, because of a considerably larger number of stems, each stem is less critical if withdrawn from forestry. Nevertheless, the demands of 10 or 20 trees per ha means a severe drawback for the total economy of birch forestry aiming at high quality. It seems reasonable to discuss a preservation of three birches per ha.

DISCUSSION AND CONCLUSIONS

In terms of ecological effects of biodiversity-promoting treatments, lack of knowledge is the main drawback in the sustainable forestry option. The only measure so far to describe biodiversity-promoting treatments is the reduction

of wood produced. No one is, for example, able to forecast the increase of endangered insect populations if 10 or 15 trees are left per ha. It is likely that many specific actions taken to enrich biodiversity will give no result at all, due to the very complex relations that exist in nature. However, it is generally a movement in the right direction. Detailed recommendations must be revised continuously.

It is obvious from the case studies that the number of trees that can be left by the landowner without severe economic loss has to be adjusted to the final spacing and values of different tree species. As was clearly seen, a definite number of preserved trees has a more serious impact in the oak than in the birch stand. Aspen and alder stands resemble the birch situation, while beech and ash stands come somewhere between oak and birch regarding tree value and final spacing. We also observed that leaving groups of trees had little effect on the loss of expected land value but may positively influence the stability of biodiversity and facilitate future logging operations. In an economic and well-managed forestry, all trees left at final cutting have high values with small variations. Therefore, it will always involve important financial losses when preserving trees. Thus, one may argue that trees should be left in poorer stands with greater variability. In such stands, the wood value of trees of low quality may be nearly negligible.

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